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VOL. 83 FRIDAY, JANUARY 10, 1936 No. 2141

The American Association for the Advancement of Science:
Dipole Attraction and Hydrogen Bond Formation in Their Relation to Solubility: PROFESSOR JOEL H. HILDEBRAND 21
Women in Science: DR. FLORENCE R. SABIN 24
Scientific Events:
The Biochemical Research Foundation of the Franklin Institute; Awards of the American Society of Civil Engineers; The Award of the Willard Gibbs Medal to Professor Roger Adams; Officers of the American Association for the Advancement of Science 26
Scientific Notes and News 29
Discussion:
Deep-focus Earthquakes and Isostasy: PROFESSOR W. T. THOM, JR. *Selenium in Nutrition:* HOWARD A. SCHNEIDER. *North American Fish-hooks:* DR. ALBERT B. REAGAN. *Termites in Central New York State:* DR. A. E. ALEXANDER 32
Scientific Books:
The Autonomic Nervous System: PROFESSOR J. F. FULTON. *The Theory of Valency:* PROFESSOR HUGH S. TAYLOR 34
Societies and Meetings:
The Tennessee Academy of Science: DR. JOHN T. MCGILL. *The Oklahoma Academy of Science:* DR. DUANE ROLLER 35
Special Articles:
Spectroscopic Similarity between Ergot (Lysergic Acid) and the Yohimbine Alkaloids: DRS. M. S. KHARASCH, D. W. STANGER, M. A. BLOODGOOD and R. R. LEGAULT. *The Ergot Alkaloids. The Structure of Lysergic Acid:* DR. WALTER A. JACOBS and DR. LYMAN C. CRAIG. *The Chromosomes of Drosophila ananassae:* PROFESSOR BERWIND P. KAUFMANN 36
Scientific Apparatus and Laboratory Methods:
Cardboard for Anatomic Reconstruction Models: PROFESSOR R. M. STRONG. *An Improved Thermoregulator:* DR. ROBERT D. STIEHLER 39
Science News 6

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal
Lancaster, Pa. Garrison, N. Y.
Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

DIPOLE ATTRACTION AND HYDROGEN BOND FORMATION IN THEIR RELATION TO SOLUBILITY*

By Professor JOEL H. HILDEBRAND

UNIVERSITY OF CALIFORNIA

THE germ of the idea of a hydrogen bond may be seen in some of the formulas of Werner involving covalent linkage; however, he avoided committing himself concerning the nature of this linkage, which was little more than a dotted line, and very different from its modern significance of a definite electron pair bond. Moore and Winmill,[1] in 1912, wrote formulas containing light and heavy lines to account for the weakness of trimethyl amine in aqueous solution, $(CH_3)_3 \equiv N\text{–}H\text{–}OH$, as compared with tetramethyl ammonium hydroxide, $(CH_3)_4 \equiv N\text{–}OH$. The former may be interpreted as the first definite representation of a hydrogen band. In the following year Pfeiffer[2] suggested as an explanation of the weakness of o-hydroxyanthraquinone that the hydrogen atom is "coordinately" bound to the oxygen atom of the adjacent carbonyl group. The first recognition of the hydrogen bond as a general phenomenon we owe to Latimer and Rodebush.[3] They called attention to the effects of hydrogen bond formation, such as the high dielectric constant of water, which ordinary dipoles do not show. Lewis[4] cited the existence of HF_2^- but not F_2^{--} as offering direct evidence of a hydrogen bond. The unusual properties of ammonia, water

* Address of the vice-president and chairman of the Section of Chemistry, American Association for the Advancement of Science, St. Louis, December, 1935.

[1] T. S. Moore and T. F. Winmill, *Jour. Chem. Soc., London*, 101: 1675, 1921.

[2] P. Pfeiffer, *Ann.*, 398: 137, 1913.

[3] W. M. Latimer and W. H. Rodebush, *Jour. Am. Chem. Soc.*, 42: 1419, 1920.

[4] G. N. Lewis, "Valence," p. 109, Chemical Catalog Company, 1923.

and hydrogen fluoride have come to be regarded largely as the effects of their hydrogen bonds. The lattice structure currently attributed to ice and to water assumes the hydrogen atoms to be placed on lines joining pairs of oxygen atoms,[5] and similar evidence exists for methanol.[6] The extraordinary stability of double molecules of acetic acid and of, apparently, six-fold polymers of hydrogen fluoride in the gaseous state[7] presents evidence of the strength which such bonds may assume. Kumler[8] has pointed out abnormalities in polarization which accompany hydrogen bond formation. The writer, in his studies of solubility, has discovered a number of solutions whose behavior is highly anomalous if the explanations are based upon dipole moment alone, but which become quite "reasonable" if account is taken of hydrogen bonds. The purpose of this paper is to present a few of the most striking of these cases.

Table 1 gives the solubilities of several organic liquids in water, together with their dipole moments. (The data quoted in this paper are available, except as noted, in the International Critical Tables.) The first four liquids, benzene, nitrobenzene, aniline and phenol, become rapidly more soluble in water in the order named. If ordinary "polarity" were responsible

TABLE 1

SOLUBILITY OF LIQUIDS IN WATER, 20°

	Per cent.	$\mu \times 10^{18}$
Benzene	0.06	0.
Nitrobenzene	0.19	4.19
Aniline	3.49	1.51
Phenol	8.2	1.70
Ethyl iodide	0.40	1.66
Ethyl alcohol	∞	1.70
Propyl chloride	0.27	2.0
Propyl iodide	0.11	1.6
Propyl alcohol	∞	1.7
Water	...	1.85

we should expect to find nitrobenzene, with by far the highest dipole moment as well as the highest dielectric constant, to be the most soluble in water; however, this is far from being the case, for it is only three times as soluble as the non-polar benzene, whereas phenol, with a much smaller moment, is 137 times as soluble. The molecular fields of the non-polar portion of these four molecular species must be nearly identical so that hydrogen bond formation appears to offer the only explanation. This is stronger in water than in ammonia, as shown, for example, by their boiling points, and we should expect phenol to associate with water in this way more strongly than does aniline, as is indeed the case.

The ethyl and propyl halides and alcohols given in Table 1 differ but little from each other in their dipole moments, hence, if their solubilities in water were due simply to electrostatic dipole attractions their solubilities should be of the same order of magnitude. Propyl chloride and iodide have solubilities paralleling their dipole moments, but the alcohols, which can form hydrogen bonds with the water, mix with it in all proportions.

Table 2 gives the per cent. deviation of the total vapor pressure curves of carbon disulfide solutions from Raoult's law. The first three liquids show deviations such as might be expected from their dipole moments, but methyl alcohol, with a much smaller moment than acetone, shows a much larger deviation, due, we may assume, to the hydrogen bonds in the alcohol which have the effect of enhancing the intermolecular forces and resisting penetration by the non-polar carbon disulfide.

TABLE 2

PER CENT. DEVIATION OF TOTAL VAPOR PRESSURE CURVE FROM RAOULT'S LAW. 20°

Carbon disulfide with	Dipole moment $\mu \times 10^{18}$ e.s.u.	Per cent. deviation
Ethyl ether	1.1	17
Chloroform	1.1	15
Acetone	2.8	59
Methyl alcohol	1.7	>70 (2 liq.)

Table 3 gives solubilities in eight liquids of the non-polar gases hydrogen and nitrogen, and the polar, hydrogen-bond forming ammonia. We see again here that dipole moment alone is of little significance. Ether, in spite of its moment of 1.14, is a better solvent for the non-polar gases than benzene. The ether dipole is sufficiently buried to do little more than enhance the molecular field, but not enough to "squeeze out" the non-polar solute. Aniline, although much less polar than nitrobenzene, is a poorer solvent, because, we believe, it "associates" with itself through the hydrogen bond. The increase in such association as we proceed through ethanol and methanol to water sharply reduces the solvent power. With ammonia as solute, the order is the reverse, since ammonia is

TABLE 3

SOLUBILITY OF GASES. MOL PER CENT.

	$\mu \times 10^{18}$ e.s.u.	H_2 20°	N_2 20°	NH_3 0°
Ether	1.14	0.061	0.124	7.9
Toluene	0.4	0.037	0.053	0.26
Benzene	0.	0.025	0.043	...
Nitrobenzene	4.08	0.015	0.026	...
Aniline	1.51	0.012	0.011	...
Ethanol	1.70	0.021	0.033	39.8
Methanol	1.68	0.015	0.022	43.9
Water	1.85	0.0015	0.0013	48.1

[5] J. D. Bernal and R. H. Fowler, *Jour. Chem. Phys.*, 1: 515, 1933. S. Katzoff, *Jour. Chem. Phys.*, 2: 841, 1934.

[6] Warren, *Phys. Rev.*, 44: 969, 1933.

[7] J. Simons and J. H. Hildebrand, *Jour. Am. Chem. Soc.*, 46: 2183, 1924.

[8] W. D. Kumler, *ibid.*, 57: 600, 1935.

able to form these bonds very strongly and thus penetrate the "associated" water molecules.

Fig. 1 shows a plot of the logarithm of the solubility

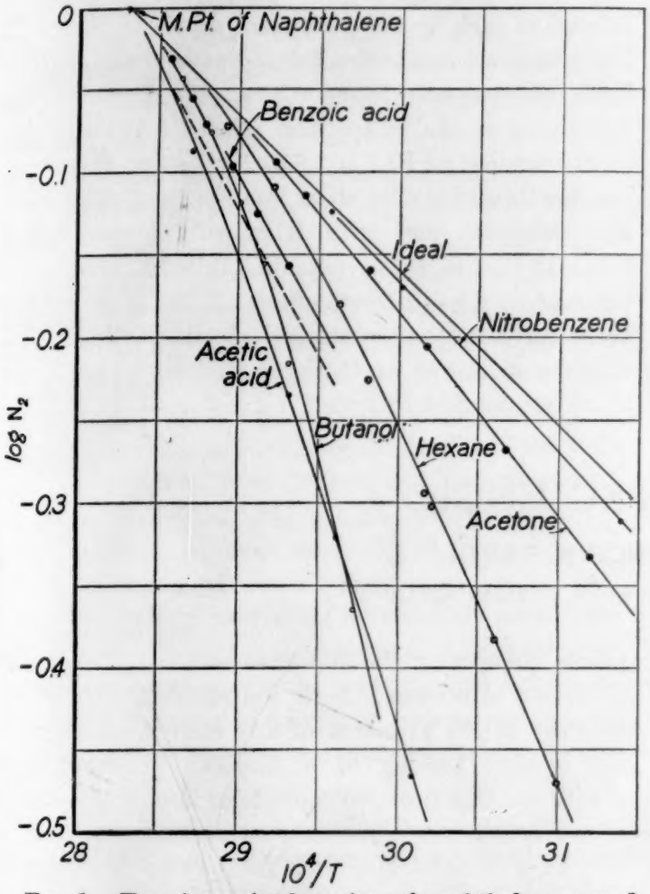


FIG. 1. Freezing point lowering of naphthalene caused by various liquids.

of naphthalene, expressed as mol fraction, in a selected list of solvents. It may be regarded as expressing the "freezing point lowering" of naphthalene. This substance has zero moment but it nevertheless forms nearly ideal solutions with nitrobenzene in spite of the high moment of the latter. Both have molecular fields about equally enhanced over that of benzene, so that their behavior indicates that the nitrobenzene molecules show but little electrostatic dipole association. Acetone with a smaller moment shows, nevertheless, a larger deviation on account of a weaker molecular field. Hexane, with a still weaker field, deviates still more, but the difference in field strengths, substituted in the approximation formula for solubility,[9] reproduced the solubility almost exactly, giving the smooth curve running through the points. Acetic acid appears to form definite dimers, doubtless through two hydrogen bonds, accordingly, its curve in dilute solutions—concentrated in naphthalene, approaches the dotted curve drawn on the assumption of complete formation of a dimer which obeys Raoult's law. Its deviation lower down accords with the difference in field strength of the hydrocarbon portions of the two species. Benzoic acid, as might be expected, forms a weaker dimer with field strength nearer to that of naphthalene. Butanol associates through the formation of hydrogen bonds, but it forms less definite polymers than the acids, and these break down more readily as they are diluted with naphthalene. The striking fact to note here is the enormous difference between butanol and acetone. The former not only has a larger hydrocarbon portion to the molecule but a much lower dipole moment, both of which should, operating alone, make it a better solvent for naphthalene. That the contrary is the case seems to admit of no other explanation than that the strength of its hydrogen bonds renders it inhospitable to naphthalene.

The difference between association due to hydrogen bonds and that due simply to dipole attraction is strikingly illustrated by Fig. 2, giving variations in

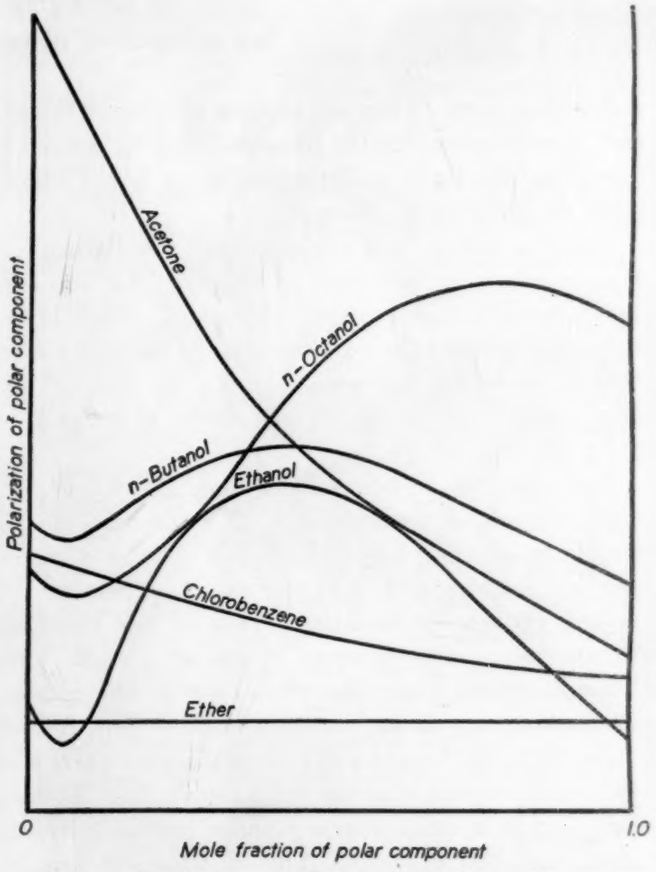


FIG. 2. Variation of molar polarization with concentration.

molar polarization with concentration in solutions with non-polar components.[10] It is evident that the alco-

[9] J. H. Hildebrand and S. E. Wood, *J. Chem. Phys.*, 1: 817, 1933; J. H. Hildebrand, *J. Am. Chem. Soc.*, 57: 866, 1935.

[10] Data from J. Krchma and J. W. Williams, *Jour. Am. Chem. Soc.*, 49: 1676, 2408, 1927; C. P. Smyth and W. N. Stoops, *ibid.*, 42: 1419, 1920. An excellent discussion of association is given by C. P. Smyth, "Dielectric Constant and Molecular Structure," Chemical Catalog Company, New York, 1931, Chap. IX. *Cf.* also C. Hennings, *Z. physik. Chem.*, B 28: 267, 1935.

hols represent a class very different from the other liquids, acetone, chlorobenzene and ether. (Nitrobenzene shows a curve similar to that of acetone but much steeper.) Any simple treatment based upon dipole attraction that might apply to the latter group would obviously not apply to the former. Indeed the enthusiasm with which dipole moments have been applied to all such problems should be strongly tempered by a realization of their inadequacy to deal with, first, molecules associated through hydrogen bonds, second, molecules of zero moment but containing vectorially opposed polar groups,[11] and, third, the intermolecular forces to the neglect of van der Waals forces. So far as this last is concerned, London[12] has calculated the magnitude of the components of the potential between molecules of HCl and of HBr. These components are, first, the van der Waals potential due to the "dispersion effect," or interaction of the electron systems, second, the interaction potential of the permanent dipoles, third, the interaction of the moments induced in each by the permanent dipole of the other. The potentials due to the induced moments are nearly negligible compared to the others. By far the largest component is the "dispersion effect." Although the dipole moment of HCl is 1.03×10^{-18} e.s.u., the potential due thereto is only about one fourth of the dispersion potential, and with HBr, with a moment of 0.78×10^{-18}, the dipole potential is only about seven per cent. of the dispersion effect. It should be evident from this that all attempts to deal with the interaction of polar molecules on the basis of their dipole forces alone are doomed to failure.

[11] J. H. Hildebrand and J. M. Carter, *Proc. Nat. Acad. Sci.*, 16: 285, 1930.

[12] F. London, *Z. Physik*, 63: 245, 1930.

WOMEN IN SCIENCE[1]

By Dr. FLORENCE R. SABIN

THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

President Park: I can not express adequately to you and to your committee the pleasure I feel in receiving this prize, for there is distinction to an honor which bears the name of M. Carey Thomas.

I confess at once that any award for work in science must awake a certain sense of timidity; for one can never be sure that research will stand. How often have the supposed facts and theories of the very ablest been reversed by new evidence! In the case of my own work, I can see with great clarity how far it is from reaching its goal.

But why does an honor from Bryn Mawr touch so deep a sense of gratification? It is because of the traditions of this place and all that they have meant for scholarship and for women. I remember so vividly getting the essential quality of this spirit on the occasion, now thirteen years ago, when Miss Thomas retired from the presidency of the college. There was not a person who spoke at that time, former members of the faculty and former students alike, who did not bring out that the influence of Miss Thomas had been in a quite unique manner toward fostering high standards of work. This is what she has bequeathed to the college. What a gratification it must be to her, President Park, that you have the same feeling for scholarship and that you have carried on and extended the high traditions of Bryn Mawr.

It seems to me fitting that I should speak of certain points concerning the influence of Miss Thomas on education in science. As is well known, the greatest function of the president of any institution of learning is the choosing of a faculty. Moreover, real ability for this function consists in having the insight to select scholars while they are still young, before they have demonstrated their full power. To use only one example, but that one striking enough, the early faculty of Bryn Mawr College included three young men who became our most distinguished biologists. Edmund B. Wilson, Thomas Hunt Morgan and Jacques Loeb have given American biology world-preeminence. It was, I think, Professor Wilson who first won from Europe full recognition for American biological research. In 1911 he was invited by the editor of the *Archiv für mikroskopische Anatomie* to republish in a foreign journal his work on the X-chromosome in relation to sex. It is interesting to recall that in this article he gave full credit to the work of Netty Stevens, who had independently and at the same time made the same discovery. As you well know, Miss Stevens did her work here and she had here a research position with almost no obligations for teaching, such as is seldom held in our universities except by the professor emeritus. Such a group of scientists as was and is still assembled here depends, of course, on the presence of the graduate school which was established at Bryn Mawr from the start along with the undergraduate department.

I want next to dwell on the influence which Miss Thomas exerted on medical education. The opening of the Johns Hopkins Medical School in 1893 was made possible by a fund raised by a group of women

[1] Response on receiving the M. Carey Thomas Prize on the occasion of the fiftieth anniversary of the founding of Bryn Mawr College.

led by Miss Thomas and Miss Mary E. Garrett, of Baltimore. The money for this fund was in the main contributed by Miss Garrett, but far more important than the actual gift of money, which determined the time of opening the new medical school, were the conditions under which the fund was given and accepted. I think that Miss Garrett would be especially pleased to have us here recognize the rôle which Miss Thomas played in this event. She laid down the conditions which were to be met, namely, a college degree or its equivalent, a knowledge of physics, chemistry and biology, proficiency in foreign languages and the admission of women on the same terms as men.

These events have not yet been adequately described, and it is to be hoped that Miss Thomas will deal with the subject in her autobiography. As new historical data, I present the following: During the last year of his life, Dr. William H. Welch told me that the conditions proposed by Miss Thomas had been discussed; that indeed he himself had outlined them in a public address without, however, any faith in the possibility of their adoption. These are great events in the history of the medical profession of which we are speaking. Certain it was that the adoption of these requirements for admission to the new medical school in Baltimore lifted the standards of the whole medical profession in this country and made medicine a graduate subject. Within a short time all the good schools raised their standards of admission and the poorest schools were closed. To make the meaning of this point clear, a short time ago I asked the dean of one of our best law schools why the legal profession had been so slow in reforming itself, in the light of new knowledge, and he replied that the main reason was that the legal profession had not yet taken the step made by the medical profession forty years ago, of establishing high requirements for admission to the study of law, so that still the poorest of law schools flourish side by side with the best.

Enough has been said to show that Miss Thomas had a profound influence on medical education. In her attitude of no compromise of standards, even when they were deemed utterly impracticable, I fancy that she had two things in mind, first, an intense belief in the value of higher education, and second, a determination that if she were to help women into professional work, it should be only for work of the highest standard. The admission of women into the Johns Hopkins Medical School on the same terms as men has opened up to women every opportunity for advanced work in medicine which they have since had. From this it is clear how great is my own personal obligation to Miss Thomas.

May I now say a word about women in science? Since we are still told that women are an inferior group in the affairs of the mind, I propose to ask the question, What new data on this subject have the past fifty years brought forth? It is important to discuss this matter dispassionately and quite without emotion —as I, for one, perhaps could not have done forty years ago. Forty years of study in science have convinced me that the book of human progress has not been closed and the possibilities of development are not yet defined. We admit at once that no great volume of scientific work has yet been done by women. But is there any work by women, judged rigidly "by the same standards as for men," which is of such high quality that it marks a milestone in scientific progress? If we can say yes, then we shall argue that nature is not so prodigal of that grade of ability as to make it wise to waste any of it.

In answer to this question, I wish to bring to your attention the work of three women, all of them European, whose work in science has this common characteristic, that it has opened up whole new fields of knowledge.

I shall not linger to prove the point about Madame Curie, for her share in opening up the subject of radio-activity and its significance in revealing the structure of matter are too well established to need emphasis.

My second name is less well known. A little more than fifty years ago, there was a young girl of nineteen in a small town of north Germany, with a strong bent for research, but when her brother went to the University of Göttingen she, according to the customs of her country, remained at home. Agnes Pockels had observed the streaming of currents when salts were put into solution and, by attaching a float to a balance, had found that salts increased the pull of the surface of the fluid. In other words, she had discovered surface tension. This was in 1881. She did not know whether any one else had ever observed this phenomenon, but, through her brother, she brought her work to the attention of the professor of physics at Göttingen. It was, however, new and he failed to grasp its significance. For ten years she went on studying the properties of solutions quite alone in her own home. Then the renowned English physicist, Lord Rayleigh, began to publish on this subject, and so she wrote to him about her work. With a fine sense of honor, he sent a translation of her letter to the English journal, Nature,[2] asking that it be published. He wrote that the first part of her letter covered nearly the same ground as his own recent work and that with very "homely appliances" she had arrived at valuable results respecting the behavior of contaminated water surfaces. It is interesting to note that it is this same "homely device" that is still used to measure surface

[2] *Nature*, 43: 437, 1891.

tension. Lord Rayleigh then added that the latter part of her letter seemed to him very suggestive, raising, if it did not fully answer, many important questions. Then for a few years he arranged for the publication of all her work in English, until the Germany of another era (1898) was proud to accept her discoveries for publication in her own language.[3]

When we state that the significance of the subject of surface tension lies in the fact that salts in solution arrange themselves in a monomolecular layer at the surface, and that the relation of every cell in the body to its surrounding medium depends upon this arrangement, we shall not have to stress further the importance of surface tension or its discovery. Agnes Pockels was one of the founders of our knowledge of this branch of physical chemistry, and none can read her letter to Lord Rayleigh and question her originality. She is now over seventy and I like to think that as she reflects on the new restrictions on the mental life of women in her country, she must know that no edict of government can subtract the fine product of her thought from the assets of mankind.

Here in Bryn Mawr College you will know the third example before she is mentioned. Emmy Noether is admitted by her peers into that small group of the world's greatest mathematicians. She was one of that brilliant group of mathematicians at Göttingen whom fate has scattered into many lands. Her field was algebra. Professor Einstein has said of her that she discovered methods which have proved of enormous importance in the development of the present-day younger generation of mathematicians; and Professor Weyl, that she originated a new and epoch-making style of thinking in algebra and, perhaps most significant of all in speaking of a woman, that her strength lay in her ability to operate abstractly with concepts. One can not read the account of her work, given by Weyl at the Memorial Service to her here at Bryn Mawr last spring, without realizing the great beauty of her power of thought. Nature endowed her with that creative insight which is only to be described by the strongest word in our language, "genius."

She was one of the great minds of our time and, when this is fully realized, then the turn of fortune, sinister and weighted with ill-will, that lost her a chance to work in her own country, yet brought her here, will be seen to have its bright side. What a happy event that Miss Thomas, with her passionate belief in women, knows that the one woman of our generation to whom the name "genius" can be applied unequivocally "on the same terms as men," should have been added to the faculty of Bryn Mawr College!

And now, President Park, Einstein has said that the last eighteen months of Emmy Noether's life, spent as they were on your faculty, were the happiest and the most fruitful of her career. Surely these words are your enduring reward. And it is clear enough that your influence has not been limited to the walls of Bryn Mawr College. All women everywhere who care for the things of the mind are in your debt. I feel especially happy that this occasion gives me the chance to be spokesman of our gratitude. Our debt is not only because throughout your administration you have held up the high traditions of this college, but far more because during a period of history when powerful forces, to use a significant medical term, seek to sensitize the mind of the whole world to prejudice, you have shown that you place intellect first.

[3] An account of her life and her bibliography are given in *Kolloid-Zeitschrift*, 58: 1, 1932.

SCIENTIFIC EVENTS

THE BIOCHEMICAL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE

THE Biochemical Research Foundation of the Franklin Institute has been formed in Philadelphia by the separation of the Cancer Research Laboratories from the University of Pennsylvania. The new foundation will have for its aims: (1) the study of disease from a chemical point of view, (2) the study of new organic compounds for their therapeutic, medicinal and curative values and (3) the study of longevity and the diseases of age with the hope of prolonging the span of life.

The new foundation, which will be a sister institution to the Bartol Research Foundation for Physics, is under the director, Dr. Ellice McDonald, and consists of forty-three workers occupying forty-seven rooms and is divided into three departments: The Department of Chemistry, Dr. E. F. Schroeder, chief; The Department of Physics, Dr. A. J. Allen, chief, and The Department of Cytology, Dr. J. O. Ely, chief. There will eventually be added departments of pharmacological research, of synthetic and organic chemistry and of therapeutics.

The new Biochemical Research Foundation will remain for the present in its former quarters, 133 South Thirty-sixth Street, Philadelphia. It maintains in addition two outside laboratories. A volume recording the work of the past year, comprising thirty-three scientific papers, will be issued in January.

AWARDS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

THE eighty-third meeting of the American Society of Civil Engineers will be held in the Engineering

Societies' Building, New York City, from January 15 to 18. At this meeting four honorary memberships in the society will be conferred by the president. The recipients are: John W. Alvord, consulting engineer, Chicago; J. F. Coleman, consulting engineer, New Orleans, and past-president of the society; Mortimer E. Cooley, dean emeritus, College of Engineering and Architecture, University of Michigan, and state engineer, PWA, Detroit, Michigan, and Col. W. J. Wilgus, consulting engineer, Ascutney, Vermont.

A posthumous award of the Norman Medal, a gold medal award instituted and endowed in 1872 by the late George H. Norman, will be presented to the late D. C. Henny, formerly a consulting engineer of Portland, Oregon, for his paper on "Stability of Straight Concrete Gravity Dams," which was adjudged the outstanding contribution of the year to engineering science. The J. James R. Croes Medal, instituted by the society in 1912, and named in honor of the first recipient of the Norman Medal, presented for the paper considered next in order of merit, will be presented jointly to A. T. Larned, civil and hydraulic engineer, Phoenix Engineering Corp., N. Y., and W. S. Merrill, hydraulic engineer, Ebasco Services, N. Y., for their paper "Actual Deflections and Temperatures in a Trial-Load Arch Dam."

The Thomas Fitch Rowland Prize, for a paper describing in detail "accomplished works of construction, their cost and errors in design and execution," will be presented to W. H. Kirkbride, chief engineer, Southern Pacific Company, Pacific Lines and Subsidiary Lines, San Francisco, for his paper on "The Martinez-Benicia Bridge." The James Laurie Prize, named in honor of the first president of the society and presented for the paper adjudged to be next in order of merit, will be presented to Wilson T. Ballard, engineer, PWA, Baltimore, Md., for his paper on "Three-Span Continuous-Truss Railroad Bridge, Cincinnati, Ohio." The Arthur M. Wellington Prize, for "papers on transportation, on land, on the water or in the air," will be presented to Hawley S. Simpson, research engineer, American Transit Association, for his paper on "Use and Capacity of City Streets." The Collingwood Prize for juniors, presented for papers describing work with which the writer has been directly connected, will be awarded to C. Maxwell Stanley, Muscatine, Iowa, junior member of the society, for a paper on "Study of Stilling-Basin Design." The Rudolph Hering Medal, for papers on sewage and sewage disposal, will be presented to the following: Robert A. Allton, sewage disposal engineer, Department of Public Service, Columbus; Orris Bonney, sewage relief engineer, Department of Public Service, Columbus; John H. Gregory, consulting engineer, professor of civil and sanitary engineering, the Johns Hopkins University, and the late R. H. Simpson, who was chief engineer of the Department of Public Service, Columbus, for a collaboration on the paper "Intercepting Sewers and Storm Stand-by Tanks at Columbus, Ohio."

THE AWARD OF THE WILLARD GIBBS MEDAL TO PROFESSOR ROGER ADAMS

PROFESSOR ROGER ADAMS, head of the department of chemistry in the University of Illinois, has been awarded the Willard Gibbs Medal of the Chicago Section of the American Chemical Society for 1936, "for outstanding and fundamental contributions to synthetic organic chemistry, and for conspicuous achievements as a teacher of chemistry." A further announcement concerning Professor Adams's work reads:

He has carried out many difficult and important organic syntheses, including new local anesthetics, chaulmoogric acid, the principal remedy for leprosy, and allied compounds. He has synthesized diphenyl derivatives and has explained how atoms have to be arranged for the molecule of the derivative to be optically active.

This work has increased knowledge of the arrangement in space of the atoms. The development of the stereochemistry of diphenyls has stimulated the use of optical rotation for studying dynamic effects within certain molecules and has offered new methods of attack to other stereochemical problems.

Professor Adams's study of diphenyl derivatives has been of high theoretical importance to organic chemistry. Diphenyl resins at present are industrially employed in the manufacture of dyes, synthetic perfumes, explosives, medicinals and paints.

Butyn is one of the best known local anesthetics synthesized by Professor Adams. Made from coal tar materials, it is similar to novocaine, but is said to be quicker in action, and is especially useful in operations on the eye.

Professor Adams discovered the constituents of chaulmoogric acid, the effective principle of chaulmoogra oil, called the "backbone of leprosy treatment." The oil, taken from the seed of a fruit similar to grapefruit, which grows on a tree of the Indian plum family in the Philippines, Siam and Indo-China, was found to check leprosy even in fairly advanced stages and to control it in early stages. Injection of the ethyl ester of the acid under the skin of the leper was reported to be most valuable.

With knowledge of the constituents, Professor Adams was able to synthesize chaulmoogric acid as well as certain analogous compounds which are believed to be even more efficient. The synthetic acid, called diheptylacetic acid, is made from castor oil and acetic acid. It is produced on a fairly large scale, thus freeing investigators from the necessity of obtaining chaulmoogra oil for their work. Extensive tests with the synthetic substances are

now being carried out in the leper colony in the Philippines.

Platinum-oxide, an extremely useful new catalyst for the reduction of organic compounds, was discovered by Professor Adams, who has also been successful in the reduction of trypanocidal compounds.

The award is determined by a national jury of scientific men. The first medallist was Svante Arrhenius of Sweden, who has been followed by: Mme. Curie of France, Sir James Irvine of Scotland, Dr. Richard Willstaetter of Munich, and American scientists including Theodore W. Richards, Leo H. Baekeland, Ira Remsen, Arthur A. Noyes, Willis R. Whitney, Edward W. Morley, William M. Burton, William A. Noyes, F. G. Cottrell, J. Stieglitz, G. N. Lewis, Moses Gomberg, John Jacob Abel, William Draper Harkins, Claude S. Hudson, Irving Langmuir, Phoebus A. Levene, Edward Curtis Franklin, Harold C. Urey, Charles A. Kraus.

OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A FULL account of the St. Louis meeting of the American Association for the Advancement of Science and of the scientific societies associated with it, edited by the permanent secretary, will be published in the issue of SCIENCE for February 7.

Officers of the association for 1936 were elected as follows:

PRESIDENT

E. G. Conklin, Princeton University, Princeton, N. J.

VICE-PRESIDENTS

Mathematics: G. C. Evans, University of California, Berkeley, Calif.

Physics: George B. Pegram, Columbia University, New York, N. Y.

Chemistry: Irving Langmuir, General Electric Company, Schenectady, N. Y.

Astronomy: Frederick H. Seares, Mount Wilson Observatory, Pasadena, Calif.

Geology and Geography: George R. Mansfield, U. S. Geological Survey, Washington, D. C.

Zoological Sciences: Ross G. Harrison, Yale University, New Haven, Conn.

Botanical Sciences: J. M. Greenman, Missouri Botanical Garden, St. Louis, Mo.

Anthropology: Ralph Linton, University of Wisconsin, Madison, Wis.

Psychology: Edward S. Robinson, Yale University, New Haven, Conn.

Social and Economic Sciences: Harold G. Moulton, Brookings Institution, Washington, D. C.

Historical and Philological Sciences: E. H. Wilkins, Oberlin College, Oberlin, Ohio.

Engineering: W. E. Wickenden, Case School of Applied Science, Cleveland, Ohio.

Medical Sciences: Joseph T. Wearn, Western Reserve University, Cleveland, Ohio.

Agriculture: P. E. Brown, Iowa State College, Ames, Iowa.

Education: E. S. Evenden, Columbia University, New York, N. Y.

MEMBERS OF THE EXECUTIVE COMMITTEE OF THE COUNCIL
(Terms to expire in December, 1939)

Karl T. Compton, Massachusetts Institute of Technology, Cambridge, Mass.

Richard C. Tolman, California Institute of Technology, Pasadena, Calif.

ELECTED MEMBERS OF THE COUNCIL
(Terms to expire December, 1939)

Austin H. Clark, U. S. National Museum, Washington, D. C.

Arthur H. Compton, University of Chicago, Chicago, Ill.

MEMBERS OF THE COMMITTEE ON GRANTS-IN-AID
(Terms to expire December, 1939)

Sam F. Trelease, Columbia University, New York, N. Y.

Joel Stebbins, University of Wisconsin, Madison, Wis.

MEMBER OF THE FINANCE COMMITTEE
(Term to expire December, 1939)

Arthur L. Day, Geophysical Laboratory, Carnegie Institution of Washington, Washington, D. C.

TRUSTEE OF SCIENCE SERVICE
(Term to expire April, 1939)

Burton E. Livingston, Laboratory of Plant Physiology, the Johns Hopkins University, Baltimore, Md.

SECRETARY OF SECTION ON AGRICULTURE
(Term to expire December, 1939)

M. F. Morgan, Connecticut Agricultural College, New Haven, Conn.

SECTION COMMITTEEMEN
(Terms to end December, 1939)

Mathematics: L. M. Graves, University of Chicago, Chicago, Ill.

Physics: Karl K. Darrow, Bell Telephone Laboratories, New York, N. Y.

Chemistry: Moses Gomberg, University of Michigan, Ann Arbor, Mich.

Astronomy: John C. Duncan, Wellesley College, Wellesley, Mass.

Geology and Geography: C. H. Behre, Northwestern University, Evanston, Ill.

Zoological Sciences: A. M. Banta, Brown University, Providence, R. I.

Botanical Sciences: E. W. Sinnott, Barnard College, New York, N. Y.

Anthropology: Robert Redfield, University of Chicago, Chicago, Ill.

Psychology: John P. Nafe, Washington University, St. Louis, Mo.

Social and Economic Sciences: Holbrook Working, Stanford University, Calif.

Historical and Philological Sciences: George Sarton, Harvard University, Cambridge, Mass.

Engineering: N. H. Heck, U. S. Coast and Geodetic Survey, Washington, D. C.
Medical Sciences: Arno B. Luckhardt, University of Chicago, Chicago, Ill.
Agriculture: R. M. Salter, Ohio State University, Columbus, Ohio.
Education: Ernest Horn, University of Iowa, Iowa City, Iowa.

SCIENTIFIC NOTES AND NEWS

As has already been announced, the annual meeting of the British Association will be held in 1936 in Blackpool on September 9–16 under the presidency of Sir Josiah Stamp. *Nature* now reports that the following sectional presidents have been appointed: Section A (Mathematical and Physical Sciences), Professor A. Ferguson; B (Chemistry), Professor J. C. Philip; C (Geology), Professor H. L. Hawkins; D (Zoology), Dr. Julian Huxley; E (Geography), Brigadier H. S. L. Winterbotham; F (Economic Science and Statistics), Dr. C. R. Fay; G (Engineering), Professor W. Cramp; H (Anthropology), Miss D. A. E. Garrod; I (Physiology), Professor R. J. S. McDowall; J (Psychology), A. W. Wolters; K (Botany), J. Ramsbottom; L (Educational Science), Sir Richard Livingstone; M (Agriculture), Professor J. Hendrick.

AT the St. Louis meeting of the American Association of University Professors, Dr. A. J. Carlson, Frank P. Hixon professor of physiology and chairman of the department at the University of Chicago, was elected president. The address at the luncheon was given by Dr. Karl T. Compton, president of the Massachusetts Institute of Technology.

DR. HOMER L. SHANTZ, since 1928 president of the University of Arizona, has been appointed chief of the Division of Wild Life Management of the Forest Service. The appointment will become effective on June 1. Dr. Shantz was connected with the U. S. Department of Agriculture from 1908 to 1926 and was then professor for two years at the University of Illinois.

THE thousand dollar prize of the American Association for the Advancement of Science, given to the author of "a noteworthy paper" presented at the annual winter meeting, has been awarded to Dr. P. W. Zimmerman and Dr. A. E. Hitchcock, of the Boyce Thompson Institute, Yonkers, N. Y. Their paper on "Responses of Plants to Growth Substances" was read before the Botanical Society of America, which met in affiliation with the association.

AT the recent meeting in Chicago of the American Society of Agronomy, J. S. McHargue, research chemist in the Agricultural Experiment Station of the University of Kentucky, received the first prize in the $5,000 awards for research on the importance of rarer elements in agriculture. Funds for the awards were provided by the Chilean Nitrate Corporation of New York. The selection was made by a committee of the society.

DR. IRVING LANGMUIR, associate director of the laboratories of the General Electric Company, has been chosen an honorary fellow in the physical sciences at Union College. Honorary fellows serve for three years. They engage to spend a short time in residence at the college twice each year, and to talk informally with staff and students.

Industrial and Engineering Chemistry reports that Dr. Charles A. Browne and the late Dr. Lafayette B. Mendel were honored on November 14 by the Associated Grocery Manufacturers of America, Inc., being presented with an award of distinction in recognition of outstanding and fundamental applications of science to the manufacture of foods, to the end that they may better serve the health of mankind. The committee recommending the awards was composed as follows: Dr. H. C. Sherman, Mitchill professor of chemistry at Columbia University; Mary Swartz Rose, professor of nutrition at Teachers College, Columbia University; Dr. Harry Steenbock, professor of agricultural chemistry at the University of Wisconsin; Dr. George R. Cowgill, associate professor of physiological chemistry at Yale University, and Dr. L. A. Maynard, professor of animal husbandry at Cornell University.

DR. J. DUFRENOY, director of the Station for Plant Pathology for southwestern France, has been awarded the Prix Bouchard by the Biological Society of France.

DR. RUDOLF RUEDEMANN, New York State paleontologist, was elected a correspondent of the Geological Society of Stockholm on December 5.

DR. R. G. D. RICHARDSON, professor of mathematics and dean of the Graduate School of Brown University, has been appointed official representative of the university, which is president of the Association of American Universities.

DR. LAWRENCE W. BASS, director of research of the Borden Company, has been elected chairman for 1936 of the New York Section of the American Chemical Society. He succeeds Professor Arthur W. Hixson, of Columbia University.

OFFICERS of the Chemical Society of Washington were elected at the annual meeting as follows: *President,* J. H. Hibben; *Secretary,* K. S. Markley; *Trea-*

surer, H. L. Haller; *Councillors,* James F. Couch (retiring president), Vincent du Vigneaud, R. E. Gibson, O. E. May and Edward Wichers. *Managers,* N. Bekkedahl, F. G. Brickwedde, N. L. Drake, Sterling B. Hendricks, Louise Stanley and F. D. Rossini. On this occasion Dr. Hugh S. Taylor, chairman of the department of chemistry, Princeton University, addressed the society on "Modern Developments in Surface Catalysis."

OFFICERS of the Philosophical Society of Washington for 1936 are: *President,* F. B. Silsbee; *Vice-presidents,* F. Wenner, R. E. Gibson; *Corresponding Secretary,* F. M. Defandorf; *Recording Secretary,* L. R. Hafstad; *Treasurer,* W. G. Brombacher; *General Committee at Large,* F. G. Brickwedde, H. E. McComb, L. V. Berkner and H. F. Stimson; *Junior Past-presidents,* H. L. Dryden and O. H. Gish; *Committee on Communications,* F. C. Kracek, *chairman,* W. Ramberg and P. A. Smith; *Committee on Membership,* I. C. Gardner, *chairman,* O. S. Reading and D. M. Little.

DR. E. LEE SHRADER, of the St. Louis University School of Medicine, was elected president of the American Student Health Association on December 28 at the closing session of its sixteenth annual meeting in New York City. Other officers for 1936 are Dr. Lee W. Milford, of Clemson Agricultural College, in South Carolina, vice-president, and Dr. Ruth E. Boynton, of the University of Minnesota, secretary-treasurer. Dr. George W. McCoy, director of the National Institute of Health, U. S. Public Health Service, was the principal speaker at the meeting, which was devoted to discussion of the control of communicable diseases.

DR. REGINALD FITZ, since 1922 associate professor of medicine in the Harvard University Medical School, has been appointed professor of medicine in the Boston University School of Medicine and director of the Robert Dawson Evans Memorial, the department of clinical research and preventive medicine of the Massachusetts Memorial Hospitals. In the latter position Dr. Fitz will succeed Dr. Henry M. Pollock, who has been director, and the late Dr. Allan Winter Rowe, director of research.

PROFESSOR JEAN F. PICCARD will conduct courses on the stratosphere at the University of Minnesota for three months, beginning in April.

DR. THOMAS NICOL has been appointed to the chair of anatomy of the University of London, tenable at King's College. He has been since 1927 senior lecturer and was for a time acting head of the department of anatomy at the University of Glasgow.

DR. E. L. HIRST, at present reader in the chemistry of plant products at Birmingham University, has been invited to fill the Alfred Capper Pass chair of chemistry at the University of Bristol on the retirement in July next of Professor Francis Francis.

DR. PAUL S. MARTIN has been appointed curator of the department of anthropology at the Field Museum of Natural History, Chicago, to fill the vacancy caused by the death late in 1934 of Dr. Berthold Laufer. Dr. Martin joined the staff of Field Museum in 1929 as assistant curator of North American archeology. Since Dr. Laufer's death he has been acting curator. Prior to his going to Field Museum, Dr. Martin was a member of the staffs of the Public Museum in Milwaukee and of the Colorado State Museum in Denver.

DR. ARTHUR W. HEDRICH, of the Johns Hopkins University School of Hygiene and Public Health, has been appointed chief of the Bureau of Vital Statistics of the Maryland State Department of Health. Dr. G. E. Bennett and Dr. J. Earle Moore, both of Baltimore, have been named consultants in the department. Dr. Hedrich is at present on a leave of absence from the university, having been loaned to the United States Public Health Service to act as director of the Chicago district in a survey of chronic diseases in their relation to permanent disability and consequent unemployment.

DR. ROBERT A. BLACK has been appointed a member of the Board of Health of Chicago, succeeding Dr. Edwin O. Jordan, who until his retirement in 1933 was professor of bacteriology and chairman of the department of bacteriology at the University of Chicago.

THE twelfth Ludvig Hektoen lecture of the Frank Billings Foundation of the Institute of Medicine of Chicago will be delivered on January 24 by Dr. John F. Fulton, Sterling professor of physiology in the Yale University School of Medicine. His subject will be "Somatic and Automatic Functions of the Frontal Lobes."

PROFESSOR ROBERT H. GAULT, of Northwestern University, on December 18 addressed the Franklin Institute on "Recent Developments in Vibro-Tactile Research."

DR. N. HAMILTON FAIRLEY, director of the London School of Tropical Medicine, gave the first Roger S. Morris Lecture at the University of Cincinnati College of Medicine on December 2 and the Frank E. Bunts Lecture at the Cleveland Clinic on December 3. He spoke on "Tropical Diseases as they Affect the Practice of Medicine in the Temperate Zone."

THE annual Morris Herzstein lectures, under the direction of the University of California and Stanford

University Medical Schools, have been set for March 2, 3 and 4. The lectures will be on preventive medicine and will be delivered by Dr. J. G. FitzGerald, dean of the faculty of medicine and director of the school of hygiene and the Connaught Laboratory at the University of Toronto.

THE School of Medicine and Dentistry and the Strong Memorial Hospital of the University of Rochester are arranging the celebration of the tenth anniversary of the opening of the hospital on January 10 and 11. Included in the program is an Eastman Memorial Lecture by Dr. Elliott P. Joslin on January 10. Other Eastman Memorial Lectures will be by Professor B. A. Houssay on January 20, by Professor Wm. H. Howell on February 14 and by Professor L. J. Henderson on March 6.

AT the sixth International Congress of Genetics held at Ithaca, New York, 1932, a Permanent International Committee of Congresses of Genetics was elected consisting of representatives of fifteen different countries, and Professor Otto L. Mohr, professor of medicine in the University of Oslo, was elected chairman. *Nature* reports that this committee has accepted the invitation of the Academy of Sciences of the U.S.S.R. to hold the seventh International Congress in Moscow and Leningrad in 1937. The date of the congress will be decided upon later. In 1937 an All-Union Agricultural Exhibition will be held in Moscow, which will prove of interest to members of the International Congress on Genetics.

THE *Journal* of the American Medical Association reports that the Orphans' Court has recently handed down a ruling giving to the University of Pennsylvania immediate control of a bequest amounting to about $2,000,000 from the estate of the late George Leib Harrison, retired chemical manufacturer, who died in March, 1935. The money will be used to endow the "George L. and Emily McMichael Harrison Memorial Fund for General Surgical Research." The bequest is subject to four annuities.

THE Johns Hopkins Hospital receives approximately $900,000 under the will of the late Albert Marburg, retired tobacco manufacturer, who died on November 9. The bequest is to be used by the trustees of the hospital without any restrictions and is to be known as the "Annie G. Marburg Fund," in memory of Mr. Marburg's wife. Princeton University receives an unrestricted bequest of $50,000 to be known as the "Albert Marburg Memorial Fund."

PRESIDENT WALTER HULLIHEN, of the University of Delaware, has announced an anonymous gift of $300,000 for the erection and equipment of a building for chemistry.

THE Massachusetts Agricultural Experiment Station has received from Mrs. Ella Lang an initial fund of $5,000 for the purpose of expanding the research program now under way in the field of human nutrition as related especially to mineral metabolism. In the further promotion of research made possible through this support there is a plan for the cooperation of several departments in the station and also for the utilization of clinical facilities at the Robert Brigham Hospital at Boston.

THE Manchester correspondent of the London *Times* reports that in response to an appeal made to them by Dr. R. H. Pickard, director of the British Cotton Industry Research Association, in an address at their annual meeting, the general committee of the Federation of Master Cotton Spinners' Associations unanimously decided to increase by 50 per cent., for a period of five years, the subscription made by the federation to the funds of the Shirley Institute. This means a grant of about £11,000 a year as the basis of the federation's financial support for the cotton research work carried on at Didsbury under Dr. Pickard. The contribution has hitherto been two fortieths of a penny per annum per spindle in the federation membership. For the next five years three fortieths of a penny per spindle will be the basis of the grant, and there are over 30,000,000 spindles in the mills of firms who are members of the federation. Dr. Pickard described to the committee the increasing number of scientific researches undertaken at the institute in the interests of the spinning section of the industry. One of the greatest services that could be rendered to the cotton industry was, he said, the strengthening of the financial resources of the institute to deal with the vertical organization of the industry on its technical side. In making their increased grant the federation committee recognized that the great increase in the institute's services to individual firms was largely responsible for the curtailment of the fundamental research work for which the association was primarily established. They did not think it was desirable that such special services to individual members should be limited or curtailed, but in granting the increase they made it clear that they expect the institute will more fully concentrate on fundamental research work.

THE annual conversazione of the British Institution of Civil Engineers was held recently at their house on Great George Street and the arrangements in connection with it included three lectures with lantern slides (on giant telescopes by the Astronomer Royal, on Robert Hooke by Dr. H. J. Gough, and on the Houston-Mount Everest Flight by Air Commodore

P. F. M. Fellowes), concerts by Miss Jelly d'Aranyi and Mr. Norman Notley, and an exhibition of engineering models and scientific apparatus. To the exhibition contributions were sent by various official bodies, such as the Science Museum, the National Physical Laboratory, the Building Research Station, the Forest Products Research Laboratory and the Woolwich Research Department. Many of the exhibits related to structural engineering (unit construction of Warren-truss Bridges, a supporting structure in tubular steel scaffolding, the underpinning of Durham Cathedral and the protection of structural steelwork after erection by means of combined metallic coatings and paint), and to road engineering (an instrument for measuring the camber and gradient of roads, plant for automatically proportioning the ingredients of concrete and road material and models and diagrams illustrating the flow of traffic at complicated circus and bridged road junctions). Among scientific apparatus Sir Robert Hadfield showed a petrological microscope and a contact thermo-couple pyrometer, with specimens of the steel used for making the turbine blades of the *Normandie;* Mr. C. C. Paterson, an instrument for viewing the response curves of radio-frequency filters, and Dr. J. S. Owens, apparatus for measuring ultra-violet radiation in daylight, a water gauge reading to 0.1 mm of water and an evaporimeter for measuring the loss of water from different surfaces. There was an exhibit of the Harlandic-Synclock synchronous time system for ships, and Imperial Airways sent models of their Scipio flying boats and Heracles air liners.

DISCUSSION

DEEP-FOCUS EARTHQUAKES AND ISOSTASY

THE demonstration that the foci of numerous earthquakes lie from 100 to 700 kilometers below the surface has come as a matter of the greatest interest to students of the earth's structure and dynamics—so much so, indeed, that some seem inclined to conclude that this discovery proves that ordinary faulting can occur to depths of 400 to 700 kilometers,[1] and consequently that subcrustal readjustment and flowage does not take place in the manner postulated by the exponents of isostasy.

Before needless scientific confusion arises because of too ready acceptance of the belief that deep-seated faulting *is* thus proven, it may not be amiss to raise the question whether these deep-focus quakes necessarily must be regarded as due to ordinary faulting (*i.e.,* due to a sudden rupture or slipping induced by accumulated, elastically stored stress) or whether such deep-focus earthquakes may not be essentially similar in origin to "volcanic" earthquakes which result from surface or near-surface volcanic explosions.

The interesting and important experiments being conducted by Dr. Bridgman at Harvard are reported to demonstrate that at great confining pressures, and under varying conditions of rotational movement, various substances undergo explosive chemical transformations or physical changes of state.[2] Compilations by Turner[3] and Sharpe[4] also show that the bulk of the deep-focus earthquakes occur in the Japanese Archipelago, the East Indies, the West Coast of South America and the Himalayas—regions in which it has already been suggested that rocks such as normally occur near the earth's surface are now deeply invaginated in denser subcrustal material. These regions should, consequently, afford unusually numerous opportunities for the occurrence of rock rupture by sudden polymorphic transformations or explosive chemical reactions—such reactions, for example, as those which apparently caused the outbursts responsible for the diamond "pipes" of South Africa and for various "crypto-volcanic" features, such as have been described by Bailey and Bucher.

Pending proof that the deep-focus earthquakes *are* due to ordinary faulting, and are not due to instantaneous rupture produced by deep-seated "explosions," it would seem to be in order to consider that their bearing on the problems of tectonics and of isostasy remains indeterminate.

W. T. THOM, JR.

PRINCETON UNIVERSITY

1 *Nature,* 136: 3446, 782–784, November 16, 1935.
2 SCIENCE (Supplement), 82: 2135, 8, November 29, 1935.
3 Int. Seismol. Summary, 1927, Jan.–Feb.–March issue.
4 SCIENCE, 82: 2135, 523–524, November 29, 1935.

SELENIUM IN NUTRITION

EVER since the indication[1] that the so-called "alkali disease" of live stock of the north-central Great Plains might be due to traces of selenium in the indigenous grains and forage, the nutritional aspects of orally ingested selenium have received increasing amounts of attention. Some of the effects of the natural toxic grain have been revealed by the outstanding work of Franke and colleagues.[2]

The toxicological action of selenium salts was first studied by Gmelin,[3] who reported the production of

1 U.S.D.A., Circular 320, August, 1934.
2 K. W. Franke, *Jour. of Nutr.,* 8: 597, 1934.
3 Gmelin, "Versuche über die Wirkungen des Baryts u. Stronians u.s.w. auf den thierischen Organismus," Tübingen, p. 43, 1824.

garlic odor in the breath and of metallic deposits in the intestinal walls. Selenium in the metallic state was described as innocuous, and the consensus of pharmacological and toxicological opinion at that time was that the toxic action of selenium salts was much the same as that of arsenic or other poisonous metals. Physiologically, reduction of selenium salts to the metallic state as, *e.g.*, by glucose, appeared to be the means of defense of the organism.

Nutritionally, selenium was regarded as of no importance. Only Gassmann[4] claimed it to be a normal constituent of human teeth and urine, but this was disclaimed by Fritsch.[5] However, in the light of the new relation to "alkali disease," consideration of the chemical similarity of selenium and sulfur and the importance of the latter in physiological oxidation-reduction systems made it seem probable that on sublethal levels of ingestion, selenium salts might play a rôle in the nutritive processes of animals.

To investigate the effects of the ingestion of inorganic selenium as distinct from the apparent organic combinations occurring in the natural toxic grain, sodium selenite was incorporated in a good stock diet for rats. At a level of 70 p.p.m. it arrested the growth of 3-weeks-old albino rats and caused emaciation and death within 2 weeks. A level of 35 p.p.m. caused slight and erratic growth, death occurring in about 6 weeks; 17.5 p.p.m. resulted in slightly subnormal growth and a variation in the lethal effect, some animals living as long as 267 days with no other symptoms than a slightly subnormal growth. Food consumption records indicated these growth effects to be due to inanition. This was verified by restricted intake experiments on control animals.

When adult rats were placed on a selenium diet at a level of 35 p.p.m. they showed the same variability in susceptibility, but in general withstood the poisoning more effectively than growing rats on the same level. After an initial inanition they gradually recovered weight and consumed normal quantities of ration. Occasionally such animals succumbed, entering a rapid cachexia and dying with the symptoms noted below. High levels of 420 p.p.m. fed to adult rats resulted in an inanition so severe that the animals virtually starved to death, although autopsy revealed subacute pathologic changes.

In acute selenium poisoning animals died after a short period (2 to 3 weeks). This category includes animals on high levels (70 p.p.m.) and those animals on lower levels which, due to individual susceptibility or constitutional weakness, died in about the same period of time. These rats lost weight rapidly or else gained weight slowly and erratically. They assumed a hunched position and were inclined to be restive. The urine became highly pigmented. Post-mortem examination revealed the liver as the seat of the most important pathological changes. When death was incident early the liver was inclined to be hemorrhagic and thin edged; when death occurred later it showed a tendency to fatty degeneration, friability and atrophy. Kidneys were also inclined to be hemorrhagic. Ascites was frequently observed.

In chronic selenium poisoning on diets low in selenium (17.5 p.p.m. and less) susceptibility was quite variable. Growth was slightly subnormal. Symptoms developed in these animals while they were still in a good nutritive state. Later the progress of cachexia was rapid, the urine became highly pigmented, and a rapid and progressive anemia developed with hemoglobin levels as low as 2.11 gm./100 cc. Liver cirrhosis, ascites, adhesions and regeneration of the liver were observed at autopsy. Heart and spleen were hypertrophied, testes and uterus atrophied. Pleural edema was frequent and an acute peritonitis was often terminal. These symptoms are identical with those reported by Franke for the natural toxic grain.

The importance of sulfhydryl in the oxidation-reduction relations of normal physiology made it seem probable that selenium might have a disturbing effect on such relations. Studies in the gross, by determination of the basic metabolic rates of rats on a 17.5 p.p.m. régime, gave no indication of significant variations from the normal. Using Rubner's formula for surface area and neglecting protein metabolism the mean basal metabolic rate of 16 experimental animals was found to be for males, 819 cal./24 hrs./sq. meter; for females, 731 cal.

The effects of metabolizable sulfur added as cystine at levels of 0.2, 0.4, 0.6 to the cystine low diet of Jackson and Block[6] did not mitigate the growth-arresting effects of selenium at a level of 35 p.p.m., nor did it have any postponing effect on the ultimate lethal action. For the more specific oxidation-reduction systems such as ascorbic acid and glutathione, determination in the livers of rats on a selenium diet showed no distinct trends in oxidizability from the range in the controls.

Early toxicologists postulated an action of selenium on the organism as a whole but did not demonstrate the toxicity for any specific cell function. By means of oxygen uptake studies in the Warburg apparatus we have demonstrated a reduction of the oxygen uptake rate in rat liver by sodium selenite when added in vitro at concentrations of M/300. Oxygen uptake was diminished approximately 50 per cent. during the first half hour and 70 per cent. during the second half hour. Diminished oxygen uptake could not be demonstrated

[4] T. Gassmann, *Zeit. Physiol. Chem.*, 97: 307, 1916; 98: 182, 1917.

[5] R. Fritsch, *Zeit. Physiol. Chem.*, 104: 59, 1918; 109: 186, 1920.

[6] R. W. Jackson and R. J. Block, *Jour. Biol. Chem.*, 98: 465, 1932.

in the livers of rats which had previously received a selenium ration at levels of 70, 35, and 177.5 p.p.m.

H. A. SCHNEIDER

UNIVERSITY OF WISCONSIN

NORTH AMERICAN FISH-HOOKS

BIREN BONNERJEA in his recent article in SCIENCE,[1] "North American Fish-Hooks," states that he has come to the conclusion that the barbs on fish-hooks (in America) might have been an original invention, concluding the article by saying, "it seems to me that ethnographers and archeologists in the field would do well to bear this [looking for proof to that end] in mind."

While in charge of the Quileute Indians at LaPush, Washington, from 1905 to 1909, the writer did much excavating about the hill on which the Indian village is situated. The first two feet of debris there included numerous Hudson Bay beads, as well as other white man's things. Below this level only aboriginal things were found, among which were many Indian fish-hooks, of the barbed-outside type, these being found often in the lowest debris exposed there, often six feet below the stratum that contained the blue trade beads. This proves conclusively that the barbed hooks were in use before the coming of the white man to that region.

ALBERT B. REAGAN

BRIGHAM YOUNG UNIVERSITY

TERMITES IN CENTRAL NEW YORK STATE

DURING a recent discussion on the distribution of Termites, mention was made of the scarcity of these interesting insects north of the Mason and Dixon line.

In the late spring of 1933, a nest of Termites (*Reticulitermes flavipes*) was discovered on the north bank of Cascadilla Creek, several hundred yards southeast of the Cornell University stadium, by Mr. Wade H. Hadley, Jr., and the writer. Note of this northern station for this species of Termite might be of interest to the entomologist.

A. E. ALEXANDER

BUFFALO MUSEUM OF SCIENCE

SCIENTIFIC BOOKS

THE AUTONOMIC NERVOUS SYSTEM

The Autonomic Nervous System. Anatomy, Physiology, and Surgical Treatment. By JAMES C. WHITE, assistant professor and tutor in surgery, Harvard Medical School, assistant visiting surgeon, Massachusetts General Hospital, Boston. xviii + 386 pp. The Macmillan Company, 1935. Price $7.00.

THIS important monograph written by a surgeon is a highly significant contribution both to the anatomy and the physiology of the autonomic nervous system. In addition it represents the most authoritative clinical discussion of surgery of the autonomic nervous system that has yet appeared. After a brief historical account of the autonomic system, in which the date and title of Eustachius' celebrated plates are erroneously stated and the name of Gaskell is not to be found, White gives an excellent brief discussion of the anatomy of the autonomic nervous system which can be safely recommended to students. Indeed it is much more complete and concise than that to be found in any current text-book of anatomy or physiology. It is to be regretted, however, that the unimaginative publishers have virtually ruined White's excellent tabular summary of the innervation of the principal organs on pages 35–46 by lack of suitable indentation and complete disregard for the niceties of typography. The chapter on general physiology is sound, but dull, suggesting that too many physiologists tried to help the conscientious author.

The most significant disclosure in the book is described on pages 92–98 in which it is pointed out that the conventional operation for removing the sympathetic supply of the upper extremities destroys the cells of origin of the post-ganglionic fibers, whereas the conventional operation for the removal of the sympathetics of the lower extremities (ablation of lumbar ganglia 1, 2, 3 leaving intact the lower lumbar and sacral ganglia) leaves the cells of origin of the post-ganglionic fibers virtually intact. When the post-ganglionic cells are removed the tissues formerly innervated by them become sensitized to adrenaline. Consequently when such an animal or a human being secretes adrenin or is given adrenaline, extreme vasoconstriction occurs in the sensitized part. This, White argues, gives an intelligent physiological explanation for the virtual failure of the conventional operation for sympathectomy of the upper extremity. Having pointed this out, White then describes a procedure for pre-ganglionic denervation of the upper extremity, and in the few cases thus far tried this gives more satisfactory immediate results than the older procedure. It is based upon the fact, originally disclosed by Langley and long overlooked, that the pre-ganglionic vasoconstrictors of the upper extremities emerge from the spinal cord at levels below the third or fourth thoracic, often extending as far down as the tenth thoracic. Consequently when the thoracic sympathetic trunk is merely cut through at Th. 3 or 4, the pre-ganglionic vasoconstrictors of the upper extremity are entirely removed and the post-ganglionic cells remain intact. Regeneration, however, may occur.

White, like Livingston, whose recent book, "The

[1] 82: 2134, p. 492.

Clinical Aspects of Visceral Neurology with Special Reference to the Surgery of the Sympathetic Nervous System," covers a somewhat similar field, is outspoken on the subject of visceral pain. He believes that certain types of pain are intimately associated with the sympathetic nervous system and since such pain is mediated by afferent fibers passing in the sympathetic trunk it can not be completely abolished in an extremity by mere section of its somatic nerves.

In the clinical sections of the book, in which no extravagant claims are made, the pathological conditions and abnormal physiological states which may be cured or ameliorated by surgical procedures involving the autonomic nervous system are discussed. Peripheral vascular diseases, especially those which fall into the Raynaud's syndrome, are discussed at length and salutary results are recorded; relief from intractable pain, *e.g.*, of the extremities and of cardiac origin, is discussed and also the problem of hypertension. In discussing the gastro-intestinal tract White points out that Hirschsprung's disease in children may be dramatically benefited by sympathetic denervation. The final section relates to surgical procedures and to the technique of alcohol injection of sympathetic ganglia which White has done so much to develop. The book is provided with good bibliographies, clear illustrations and an excellent index.

YALE UNIVERSITY J. F. FULTON

THE THEORY OF VALENCY

The Optical Basis of the Theory of Valency. By R. DE L. KRONIG, University of Groningen. The Macmillan Company, New York. x + 246 pp. Price, $4.50.

THIS new volume in the Cambridge Series of Physical Chemistry is an excellent general survey of the contributions of modern physics to the problem of chemical valence. For the chemically stable molecules x-ray and electron diffraction studies are available. The chemically unstable molecules, the chemists' free radicals, may be studied by spectroscopic methods, which are applicable also to the stable molecules, both diatomic and polyatomic, to the latter with ever-increasing success. All these studies are contributing to a quantitative picture of the configuration, shape, size and interatomic motions and forces of molecules. The author has stated the results of mathematical physical analyses of these problems, but without any detailed derivation. This constitutes at once an advantage and a limitation of the book. The beginner in this field and those specializing in other fields anxious to know, in general, what has been accomplished will find the book an excellent introduction. The basic material necessary to an understanding of the approach to chemical binding, as interpreted by Heitler-London, Slater-Pauling and Hund-Mulliken, is presented in outline. The stability of valence compounds as revealed by reaction rate theory is considered to lie outside the scope of the book. The editor of the series might bear this in mind when considering other volumes to be presented. The recent article by van Vleck and Sherman in Reviews of Modern Physics on "The Quantum Theory of Valence" is an illustration of a more advanced treatment of the subject to which this present volume forms a satisfactory introduction.

HUGH S. TAYLOR

PRINCETON UNIVERSITY

SOCIETIES AND MEETINGS

THE TENNESSEE ACADEMY OF SCIENCE

THE November meeting of the academy for 1935 was held on Friday and Saturday, November 29 and 30, at George Peabody College, Nashville, Tennessee.

The most noteworthy feature of the meeting was its generality. Twenty-five of the forty-three papers listed on the program were by representatives of twelve different schools: the University of Tennessee, a state college and a church college, in East Tennessee; Vanderbilt University, Peabody College, two state colleges, a church college and a city school in Middle Tennessee; two church colleges in West Tennessee; a high school in Kentucky. No two schools were of the same denomination. Seven papers were by representatives of five different departments of the state. The Tennessee Valley Authority contributed two papers, the U. S. Weather Bureau one, the National Park Service one. The program committee classified the papers listed for the general section under fourteen branches of science—geology leading with five, biology next with three.

Ferns claimed chief attention at the session of the botanical section, Dr. L. R. Hester, chairman. Other subjects included trees, bryophyles, algae and fungi. Dr. George R. Gage, of Vanderbilt University, reported that the Dutch elm disease has not yet been detected in Tennessee.

The presidential address was delivered by Dr. George M. Hall, professor of geology, University of Tennessee, at the dinner at the Hermitage Hotel on Friday evening. His subject was "The Economical and Cultural Value of Geology." On Saturday afternoon, Professors Jesse M. Shaver and Aaron J. Sharp led an excursion in search of native ferns and mosses.

The editor of the *Journal of the Tennessee Academy*

of Science was directed to advertise for sale copies of the "Life and Works of Doctor Augustin Gattinger" by Henry Nathaniel Oakes, published by the academy. The grant for scientific research allotted to the academy by the American Association for the Advancement of Science was awarded to Nathan H. Woodruff, of Donelson, Tennessee, to continue at Peabody College his research on the "acidity of soils at the roots of ferns in Tennessee." Dr. Charles G. Shoup, assistant professor of biology, Vanderbilt University, was elected a member of the board of trustees of the Reelfoot Lake Biological Station for the term of three years.

Officers elected for the year 1936 are: Claude R. Fountain, *president,* Nashville; Paul J. Kruesi, *vice-president,* Chattanooga; John T. McGill, *secretary-treasurer,* Nashville; Jesse M. Shaver, *editor,* Nashville; Eleanor Eggleston, *librarian,* Nashville.

JOHN T. MCGILL,
Secretary-treasurer

THE OKLAHOMA ACADEMY OF SCIENCE

THE twenty-fourth annual meeting of the Oklahoma Academy of Science was held at the University of Oklahoma, Norman, Okla., on December 6 and 7, 1935. The academy program was divided into four sections which were as follows: Biology, Geology, Physical Sciences and Social Sciences. One hundred and twenty-eight papers were presented. A special section was arranged for high-school science teachers. The total membership in the Oklahoma Academy of Science is 387.

Dr. D. W. Ohern, geologist from Oklahoma City, Okla., gave the annual address to the academy on Friday evening in the university auditorium. The subject of this lecture was "Science in the Thought of To-day." Dr. Ohern was president of the Oklahoma Academy of Science in 1910.

Dr. Charles E. Decker gave the presidential address at the luncheon on Saturday. His subject was "The Oklahoma Academy of Science in Relation to the Advancement of Science and Research in the State."

More than 300 people were present at the meetings. The officers elected for 1936 are as follows:

President, Dr. Horace J. Harper, Oklahoma A. and M. College, Stillwater, Okla.

Vice-president, Section A (Biology), Dr. T. C. Carter, Northwestern State Teachers College, Alva, Okla.

Vice-president, Section B (Geology), Dr. Robert H. Dott, Oklahoma Geological Survey, Norman, Okla.

Vice-president, Section C (Physical Sciences), Dr. A. T. Goble, University of Tulsa, Tulsa, Okla.

Vice-president, Section D (Social Sciences), Dr. L. B. Hoisington, University of Oklahoma, Norman, Okla.

Secretary-treasurer, Dr. Duane Roller, Oklahoma University, Norman, Okla.

Assistant secretary-treasurer, Professor H. I. Featherly, Oklahoma A. and M. College, Stillwater, Okla.

DUANE ROLLER,
Secretary

SPECIAL ARTICLES

SPECTROSCOPIC SIMILARITY BETWEEN ERGOT (LYSERGIC ACID) AND THE YOHIMBINE ALKALOIDS

IN a previous communication,[1] announcing the isolation of ergotocin (the orally effective principle of ergot), the writers reported the alkaline hydrolysis products of ergotocin to be lysergic acid and a base which was at that time the object of further study. In the meantime Jacobs and Craig[2] have identified this basic hydrolysis product as propanolamine; our independent study, not previously reported, has led to the same result.

The degradation reactions commonly employed in establishing the constitutions of natural substances usually give very low yields of identifiable products; hence it seemed desirable, in view of the minute quantities of material available for the investigation of ergotocin to seek other means of attack. Comparison of the ultra-violet absorption spectra of ergotocin and its derivatives with those of other presumably related substances has proved a promising avenue of approach.

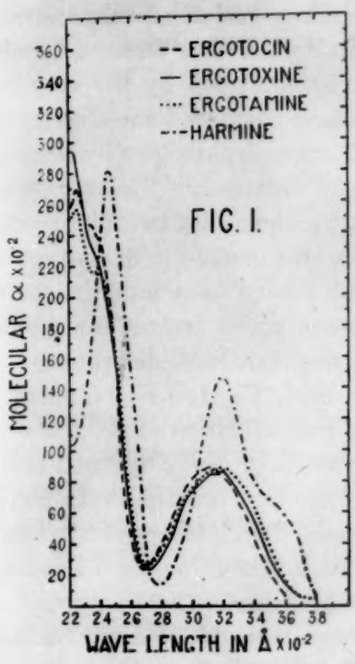
Early in this study we were impressed by the marked similarity in the molecular absorption curves for ergotoxine, ergotamine and ergotocin (Fig. 1). Probably these three substances have a common structural skeleton (lysergic acid) chiefly responsible for their respective ultra-violet absorptions.

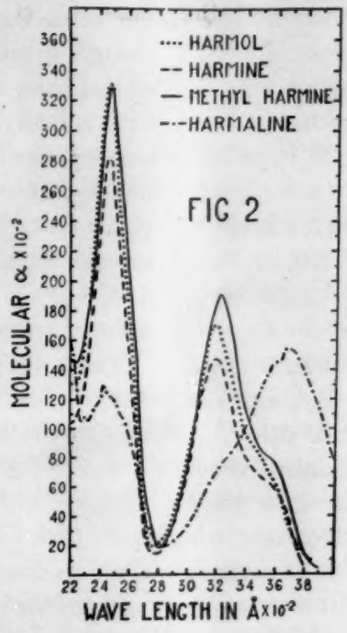
That ergotocin might be structurally related to the harmala alkaloids is suggested by the similar fluorescence of their solutions; this possibility was, however, rejected after a comparison of the absorption curve of ergotocin with those of harmol, harmine, methyl harmine, harmaline[3] and tetrahydroharmine (Figs. 1 and 2).

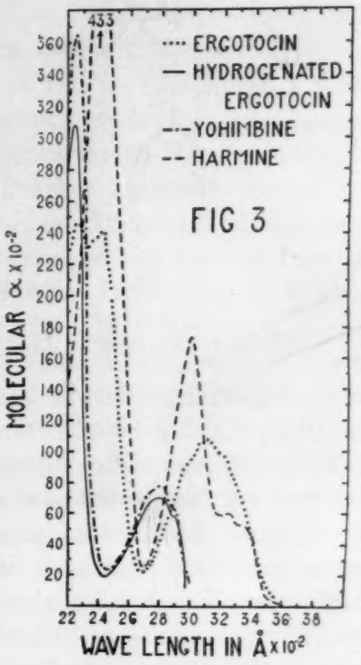
[1] M. S. Kharasch and R. R. Legault, SCIENCE, 81: 388, 1935; *Jour. Am. Chem. Soc.,* 57: 1140, 1935.

[2] W. A. Jacobs and L. C. Craig, SCIENCE, 82: 16, 1935.

[3] For purposes of record it seems desirable to report that the same possibility of relationship had occurred to H. A. Shonle and E. C. Kleiderer, of the Eli Lilly Research Laboratories, early in June, 1935. At that time they prepared for publication and submitted to us for comment a note suggesting this relationship. Upon examination of our absorption curves, however, they withheld publication. We still believe that these curves constitute more cogent arguments against the structural relationship of ergotocin



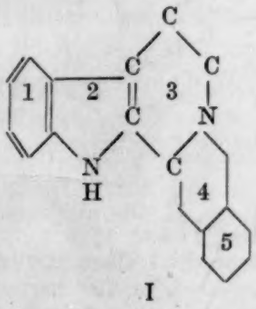




The further study of absorption spectra revealed that the curve of yohimbine is strikingly similar to that of ergotocin in shape, but somewhat displaced toward the shorter wave-lengths (see Fig. 3). We therefore undertook the platinum-catalyzed hydrogenation of ergotocin.

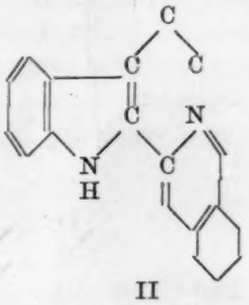
The specific rotation of hydrogenated ergotocin (m.p., 223° C. uncorr.) in methyl alcohol is about −70°, as compared with the specific rotation, +40.2° of ergotocin. The maleate and succinate salts of hydrogenated ergotocin are also laevorotatory in water solution, while those of ergotocin are dextrorotatory.[4] The ultra-violet absorption curves of hydrogenated ergotocin and yohimbine are almost identical (see Fig. 3). It is therefore probable that ergotocin and yohimbine have closely related structural skeletons; in fact, these skeletons may well be identical.

Rather drastic degradations (*e.g.*, alkali fusion or selenium dehydrogenation) have been used to derive the proposed structural formula of yohimbine. The most recent of these (that of Scholz[5]) has the following skeleton:

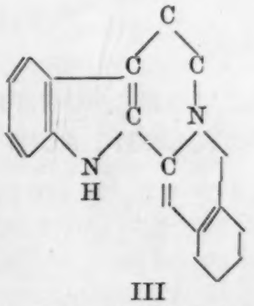


I

If Scholz's formula and the relationship above suggested are indeed correct, the ergot alkaloids, including ergotocin (and therefore lysergic acid) must have the *tetracyclic* structural nucleus represented by rings 1 to 4 inclusive. In the opinion of the writers, however, there is still reasonable uncertainty as to the exact constitution of yohimbine—note the new structure (II) assigned to tetrahydroyobyrine by Scholz.[4]



II
Tetrahydroyobyrine
(Scholz, 1935)

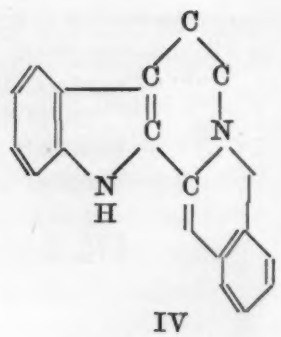


III
Tetrahydroyobrine
(Barger and Scholz, 1933)

(and therefore lysergic acid) to the harmala alkaloids than are furnished by the rather meager experimental comparisons recently cited by Jacobs and Craig (W. A. Jacobs and L. C. Craig, *Jour. Biol. Chem.*, 111: 455, 1935) in favor of such a relationship.

[4] The hydrogenated ergotocin maleate is similar to ergotocin maleate in causing powerful uterine contractions in a 0.2 mg dose when administered intraveneously.

[5] Scholz, *Helv. Chim. Acta*, 18: 923–33, 1935. See also Barger and Scholz, *ibid.*, 16: 1353, 1933.



IV

Yobyrine
(Barger and Scholz, 1933)

The writers believe that definite conclusions as to the structural relationship between the ergot and the yohimbine alkaloids, tetrahydroyobrine and yobyrine, may be drawn from further study of the ultra-violet absorption spectra of these compounds and their hydrogenation products. Syntheses of the tetracyclic nuclear structure illustrated by rings 1 to 4 in I and of the corresponding tricyclic nuclei obtained by breaking either the C—N or the C—C bond between rings 3 and 4 are now under way in this laboratory.

We hope that this announcement of the probable close skeletal relationship between yohimbine and the ergot alkaloids, together with the statement of the work now under way in this laboratory, will be regarded by other investigators as a justifiable reservation of this approach to the problem. Their courtesy and consideration will be gratefully appreciated by the writers.

The writers are indebted to Drs. T. Hogness and P. Zscheile, Rockefeller Foundation grant fellow, for the absorption spectra measurements, and to the Eli Lilly Company for a supply of ergotocin.

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R. R. LEGAULT
BUCKNELL UNIVERSITY[6]

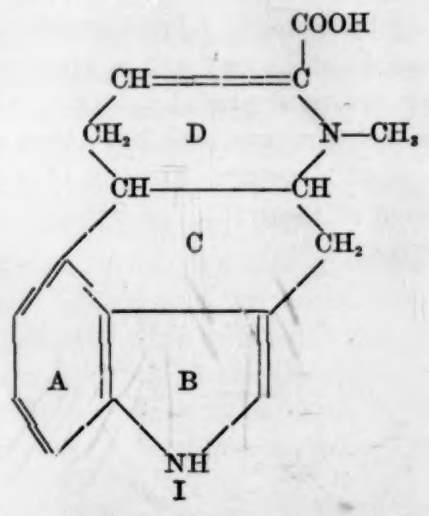
THE ERGOT ALKALOIDS. THE STRUCTURE OF LYSERGIC ACID

A PROVISIONAL structure for lysergic acid,[1] *viz.*, 3-propenyl-3, 4-dihydro-4-methylcarboline-5-carbonic acid, was suggested on the basis of the interpretation of its properties, of its degradation products and of a possible analogy to other alkaloids biogenetically related to tryptophane. More recent observations, however, have brought the conviction that this view must be revised. The nature of the previously reported product of the alkali fusion of dihydrolysergic acid, the base $C_{11}H_{11}N$, has now been determined. Although greatly handicapped by the very small yield of this base, we have convinced ourselves of its identity with 1-methyl-5-aminonaphthalene by comparison with that synthetically obtained.[2] The formation of this amine makes it probable that two fused six-membered rings enter into the make-up of lysergic acid and emerge on alkali fusion as a naphthalene derivative, and that the amino group is produced by cleavage of a fused pyrrol ring (an indol derivative).

The tribasic acid, $C_{14}H_9O_8N$, obtained in earlier work[3] by nitric acid oxidation of ergotinine and which retains the *N* methyl group of lysergic acid, has been found to yield quinoline, isolated as the picrate, on distillation with soda lime. It appears probable, therefore, that this acid is a quinoline derivative and possibly an N-methyl quinoline betaine tricarboxylic acid, as suggested by formula II. Picric acid has also been isolated from the nitric acid oxidation of lysergic acid, an observation compatible with an indol structure.

Finally, lysergic acid on catalytic hydrogenation yields at first dihydrolysergic acid which, contrary to the former, can no longer be titrated, indicating the proximity of the double bond and carboxyl group in the ring containing the $N \cdot CH_3$ group. Further hydrogenation appears to attack the indol ring system. The behavior of lysergic acid on hydrogenation leaves little doubt that it must be tetracyclic.

These observations, which together with other general considerations will be discussed more fully elsewhere, suggest a possible structure[4] for lysergic acid as presented in formula I. Oxidative cleavage with nitric acid of Rings A and B could give the tribasic



I

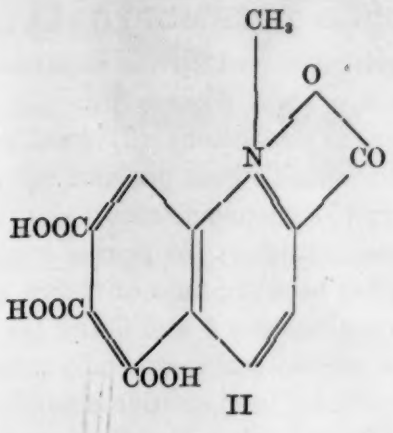
[6] At Bucknell University since September 15, 1935.

[1] W. A. Jacobs and L. C. Craig, *Jour. Biol. Chem.*, 111: 455, 1935.

[2] V. Veselý, F. Stursa, H. Olejnicek and E. Rein, *Coll. Czech. Chem. Commun.*, 1: 506, 1929.

[3] W. A. Jacobs, *Jour. Biol. Chem.*, 97: 739, 1932.

[4] The position assigned to the carboxyl group and double bond in Ring D in this formula, as well as the size of the betaine ring, in II is still arbitrary. There is also possibility that production of lysergic acid itself from the alkaloid may involve stereochemical rearrangements or a shift of the double bond in a precursor.



II

acid II. The already reported production of propionic acid on alkali fusion appears to be compatible with the cleavage of Ring D. Likewise the methyl group of the above methyl naphthylamine can be formed by cleavage of Ring D. And finally, the dimethylaminobenzaldehyde reaction given by lysergic acid would be expected from this formula since the α position of the indole nucleus is free. In the older carboline formula this point remained a difficulty.

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LYMAN C. CRAIG

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FOR MEDICAL RESEARCH
NEW YORK, N. Y.

THE CHROMOSOMES OF DROSOPHILA ANANASSAE[1]

DURING the autumn of 1933, *Drosophila ananassae* De Meijere (*D. caribbea* Sturtevant) was found frequently in Tuscaloosa, Alabama. Cytological examination of neurocytes of male larvae showed the presence of a J-shaped Y-chromosome. The stock differs, therefore, from the Panama and Cuba material with a rod-shaped Y, used by Metz[2] in his original description of the chromosomes of this species. Recently, through the kindness of Dr. W. P. Spencer, I have been privileged to examine a stock of *D. ananassae* from Dr. H. Kikkawa's laboratory in Kyoto. This also has a J-shaped Y. Further knowledge of the extent of distribution of the two types of Y-chromosome within the species awaits the study of material from those regions of tropical America from which *D. caribbea* has been reported.[3]

There are eight chromosomes in diploid cells of *D. ananassae;* four pairs of V-shaped chromosomes in the female; three pairs of V-shaped autosomes, a V-shaped X and the Y in the male. One pair of the autosomes are considerably shorter than the others. In the aceto-carmine preparations used for the present study, two of the longer autosomes show the same type of pronounced sub-median constriction which exists in the left arm of the second chromosome of *D. melanogaster.*[4] The other pair of long autosomes have constrictions in positions similar to those of the third chromosomes of *D. melanogaster.* The short autosomes are attached to the nucleolus (or nucleoli) during early prophase stages in ganglion cells of both sexes. In the male, however, the Y-chromosome forms the third member of a group which is associated with the nucleolus. The absence of a nucleolus-forming region from the X-chromosome of this species contrasts with the condition in other species of Drosophila, in which the nucleolus develops in the X.[4, 5]

Several of the ganglia studied, both male and female, contained patches of tetraploid tissue. Trisomics and XO individuals also were found.

BERWIND P. KAUFMANN
UNIVERSITY OF ALABAMA

SCIENTIFIC APPARATUS AND LABORATORY METHODS

CARDBOARD FOR ANATOMIC RECONSTRUCTION MODELS

IN 1905 (published in 1907) Mrs. S. P. Gage[1] demonstrated a method for making reconstruction models from microscopic sections, which involved the use of blotting paper instead of the usually employed wax. The technique of this method was further developed by Dr. S. W. Miller in 1931[2] and 1932.[3] He also described apparatus for cutting and mounting the paper sections. Blotting paper has the following advantages over wax: (1) it is less expensive, (2) the labor involved in rolling plates is saved, (3) it is not softened in hot weather, and (4) the resulting models are much more durable in other respects. A material which is still better than blotting paper, in my judgment, is described in this article.

About three years ago, I attempted to get blotting paper of uniform and special thickness. I was informed, however, by the paper dealers whom I consulted that only one thickness was available in large sheets and that was not uniform. I learned, however,

[1] A preliminary note.
[1] *Anat. Rec.*, 7: 166–169.
[2] *Anat. Rec.*, 48: 191–196.
[3] *Anat. Rec.*, 51: 249–250.

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[3] A. H. Sturtevant, Publ. 301, Carnegie Inst. of Wash., 1921.
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that a cardboard could be obtained which is exceedingly uniform in thickness. Furthermore, ten different grades of thickness are available.

This cardboard comes in sheets 22 × 28 inches in area and they are called "ruby blanks." The five-ply is .547 millimeters in thickness. The one-ply is one half as thick and the ten-ply twice as thick. The other grades are intermediate. I have obtained our supply from Bradner Smith and Company, 333 S. Des Plaines Street, Chicago. A recent order for one hundred five-ply blanks cost $3.15.

These ruby blanks are easier to cut with a smooth edge than blotting paper and, being harder, the pieces stand up better in patterns involving small parts. The variety of thicknesses is a great advantage, as it is possible to choose a thickness adopted to the magnification desired.

So far, we have used only the five-ply grade, which happens to have been convenient for the type of work we have been doing. Drawings are made directly on this paper, and the less complicated features are cut with shears. When the pattern is complicated, a scroll saw is employed.

In order to determine the effect of paste on the thickness of a model, a number of small squares of the paper were pasted together and dried in a paper press. The total thickness of the dried pack, when divided by the number of pieces, gives the exact thickness value of each piece in a finished model, if reasonable care is used in the application of the cementing medium and in the amount of pressure applied in the press.

The scroll saw used is made by the Delta Manufacturing Company, 3775 N. Holton Street, Milwaukee, Wisconsin, and it has the catalog number 700. A large variety of saw blades is available. We have found blade No. 16054-24J to be a convenient and durable size for cutting cardboard. Files and sandpaper pads are made for this outfit, and they save much labor in polishing surfaces of the "piled" model. We have used plastic wood to fill in large irregularities. Lacquers are convenient for painting, as they dry in a few moments, and one can pass rapidly from one color to another. The scroll saw mentioned above can not be set so quickly for interior cutting as the "cutawl" used by Professor Miller, though it takes only a moment or so to do it. The "cutawl" has only one end of the blade mounted, the other end being free, whereas both ends of the scroll saw blade are locked, and one must be freed to make the change. I believe the scroll saw is a more useful machine because of the greater variety of work it can do both in making models and in other laboratory work.

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AN IMPROVED THERMOREGULATOR

THE chief requirements which the expansible fluid in a thermoregulator must possess are: (1) A high coefficient of thermal expansion; (2) good heat conduction; (3) a low specific heat per unit volume; (4) chemical stability; (5) inexpensiveness; and (6) a low density. In thermoregulators for precise temperature control, mercury has been the fluid of choice, although it fails to meet requirements 5 and 6 and is only fair regarding 1. Organic solvents, especially toluene, and gases have been used for less sensitive regulators. The objection against these fluids is that they are poor heat conductors.

During the past year, an improved toluene regulator was employed in this laboratory to control the temperature of a gas-heated thermostat to ± .01° C. (the precision with the usual toluene regulator is ± .05° C.). The increased precision is due to placing a rapidly conducting metal foil, such as copper, in the bulb of the ordinary regulator, as shown in Fig. 1. This

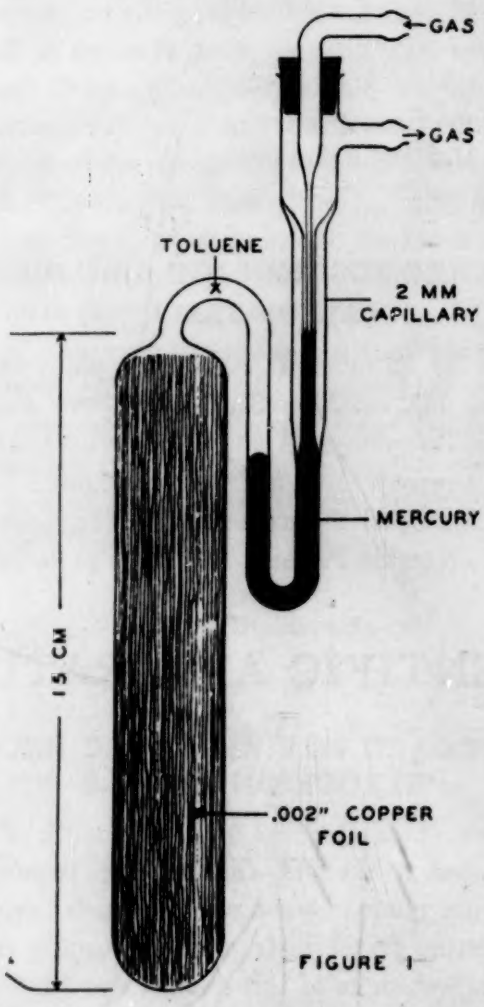

FIGURE 1

principle can be extended to any regulator using an inert organic solvent or gas. By the use of a smaller capillary and electrical control a degree of sensitivity should be attained which equals or surpasses the best mercury regulators.

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